OBSTACLE AVOIDANCE LEGGED ROBOT.

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DECLARATION

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Date : 21 NOVEMBER 2008.

DEDICATION

Specially dedicate to

My beloved parents, brothers and sisters.

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I also deeply thank to my family who's always giving a motivational support and show me a guidance to pursue my studies at University Malaysia Pahang. Thanks for their encouragement, support, love, my brothers, sister and many more. ALHAMDULILLAH.

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ABSTRACT

Many mobile robots require an operator's vision and intelligence for guidance and navigation. Animals use sensory systems such as hearing, and tactile to move freely through their environment. The aim of this project is to develop an avoidance behaviors program for a mobile robot that consists of 8 servo motors that been employed at 4 legs. Each leg contains 2 servo motors, one for X-axis and one for Y-axis. A PIC Microcontroller has been implemented to act as a brain for the robot that controls the walking and turning algorithm. Ultrasonic sensor was also developed to act as an 'eye' to the system and tells the brain about existence of obstacle in front. As a resultant, the obstacle avoidance legged robot system is been successfully developed that allows and will navigate the robot to move through the environment freely. But there is a certain limitation for the robot such as the wideness of the area, type of obstacle and surface.

ABSTRAK

Di dalam dunia permodenan dan kontemporari seperti ini robot memerlukan operator dan kebijaksanaan wawasan untuk tujuan panduan hala tujunya. Demikian adalah cara yang digunakan haiwan iaitu sistem-sistem deria pendengaran, dan sentuhan untuk bergerak dengan lebih bebas menerusi alam sekitar mereka. Matlamat projek ini adalah untuk membangunkan satu pergerakan pengelakan atur cara untuk satu kepergerakan robot yang mengandungi 8 servo motor yang berfungsi di setiap kaki. Keseluruhan robot itu mempunyai 4 kaki dan pada tiap kaki mengandungi 2 servo motor , satu untuk pergerakkan paksi X dan satu lagi untuk pergerakkan paksi Y. Satu PIC Microcontroller telah digunakan dan ia berfungsi sebagai satu otak untuk mengawal robot itu dengan wujudnya algoritma berjalan dan algoritma selekoh. Deria ultrasonik juga dibuat supaya ia berfungsi sebagai satu 'mata' bagi robot itu.

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LIST OF SYMBOL.

ms	-	Millisecond.
I/O	-	Input Output.
IC	-	Integrated Circuit.
R	-	Resistor.
C	-	Capacitor.
Cθ	-	cos (θ)
Sθ	-	sin (θ)
LED	-	Light Emitter Diode.
IR	-	Infrared.
k	-	Kilogram.
V	-	Voltage.
mA	-	mili ampere.
kg	-	kilo gram.
PWM	-	Pulse Width Modulation
ADC	-	Analog Digital Converter
PIC	-	Programmable Interface Controller

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CHAPTER 1

INTRODUCTION

1.1 OVERVIEW.

Robots are designed to be controlled by a controller, computer or similar devices. Basically mobile robots require an operator's vision and intelligence for guidance and navigation. The movement for the robot itself has many methods such as wheels, legs and many more. This movement method is to ensure the smoothness of moving in different type of surfaces.

A simple wheeled vehicle is easy in mechanical design, controlling, and the construction part. But it doesn't work efficiently in all kind of surface. On a rough terrain, it performs poorly. The radius of a wheel could pass only a certain height of obstacle. To pass most of the obstacle that it meets, larger wheel radius need to be designed. However, this approach is impractical in many cases.

On the other side, legged robots are more capable of moving across rough terrain. That's why the legged locomotion became a research of interest. But the legged robots are much more challenging to control compared wheel robots. Each leg consists of at least two motors. Controlling the one motor for left and right and another motor for

up and down is difficult. An algorithm for walking must be developed in order the robot to walk. As a result, legged robots movement must be carefully studied and be controlled in such way so that it could stand and walk in a stable fashion.

1.2 OBJECTIVE OF THE PROJECT.

The aim of this project is to develop an avoidance behaviors program for a mobile robot that consists of 4 legs that employs 8 servo motors. A PIC Microcontroller is been implemented to act as the brain for the robot that controls the walking and turning algorithm. The system and the programming will be able to control the movement of the legged so the robot able to walk straight ahead, make left turns and avoid obstacle.

1.3 SCOPE OF PROJECT.

Several scopes have been outlined to achieve this project. Scope of this project includes developing a program using high level language PIC Basic Pro for the PIC16F877A microcontroller, constructing the hardware module for it, attachment of servo motors and integration of ultrasonic sensor with the microcontroller. Developing an algorithm program for the robot to walk ahead, make a left turn and is capable to avoid obstacle.

1.4 OUTLINE OF THESIS.

This thesis consists of five chapters. This chapter is discussed about the background of robot, the objective, and scope of the project. In chapter 2 is more towards reviewing about literature study. It discusses about the function of the servo motor and it could be operated using PWM, about details of PIC16F877A microcontroller, about other robotic research that been done and about various type of sensor. In chapter 3 is been discussed about methodology for hardware and software implementation into the project. The result, analysis and discussion will be on the chapter 4. Finally, chapter 5 discusses the conclusion of the project and future work that can be done to improvise this project.

CHAPTER 2

THEORY AND LITERATURE REVIEW

2.1 INTRODUCTION.

This chapter is upon the study on servo motor, PIC microcontroller, robots analysis and sensors. Servo motor was reviewed upon controlling it using PWM and how it could be used as a device that controls a degree of freedom in a quadruped robot. The PIC microcontroller discussed more towards the capability of it and thorough detail on the functions and the operations of it. Type of sensors compared in this chapter.

2.2 SERVO MOTORS.

Servo motors are commonly used in robotics especially that uses leg for movement purpose for the robot. This was because they are light-weighted, compact and durable. Since their control and power electronics were all built-in, interfacing hardware

requirement is much simplified. Compared to toy motors, the torque of servo motors are high so the servo motors better suited to robot development.

Each servo motor has three wires, that is yellow, red and black. As shown in Figure 2.0 red is for power, black is for ground, and yellow is for pulse-width modulation (PWM) pulsing. This pulsing controls the position which the shaft of a servo motor should rotate.

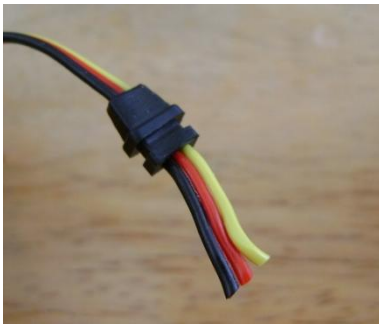

Figure 2.0: Wires for the servo motor, black (ground), red (power), yellow (PWM)

Figure 2.1 shows the servo motor dimension that been used in this project, the servo motor that been used is Hitec HS -322HD servo motor. The specification of the servo is show in Table 2.0.

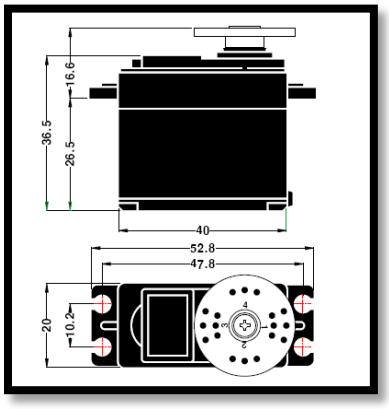

Figure 2.1: Servo motor Hitec HS -322HD dimension. (The dimension in mm)

Table 2.0: Hitec HS-322HD servo motor specification [1].

Operating voltage range	4.8V to 6V	
Test Voltage	**4.8V**	**6V**
Operating speed	0.19s/ 60° at no load	0.15s/ 60° at no load
Stall Torque	3kg. cm	3.7kg. cm
Ideal current at stopped	7.4mA	7.7mA
Running current	160mA/ 60° at no load	180mA/ 60° at no load
Stall current	700mA	800mA
Motor type	Cored metal brush	
Potentiometer type	4 slide/ direct drive	
Amplifier type	Analog controller and transistor drive.	
Dimension	40 x 20 x 36.5mm	
Weight	43g	
Ball bearing	Top/ Resin bushing	
Gear material	2 heavy duty resin	
Horn gear spline	24 segments	
Connector wire length	300mm	

2.2.1 PULSE WIDTH MODULATION FOR SERVO

Pulse-width modulated (PWM) signal is a train of pulses with varying width. Each servo motor does have its own unique pulsing width. But these listed configurations are for the servos that have been used in this project that is HS-322HD. The full duty cycle or called period for a whole pulsing must be 20ms. Figure 2.2, shows the movement of the degree upon the timeline (PWM) of the duty cycle produced. The time of 0.6ms, 1.5ms and 2.4 ms signaled the motor shaft to turn to 0 degree, 90 degrees and 180 degrees respectively. The motor shaft could not go any further than below 0 degree and above 180 degree range unless modifications were made to the servo motor.

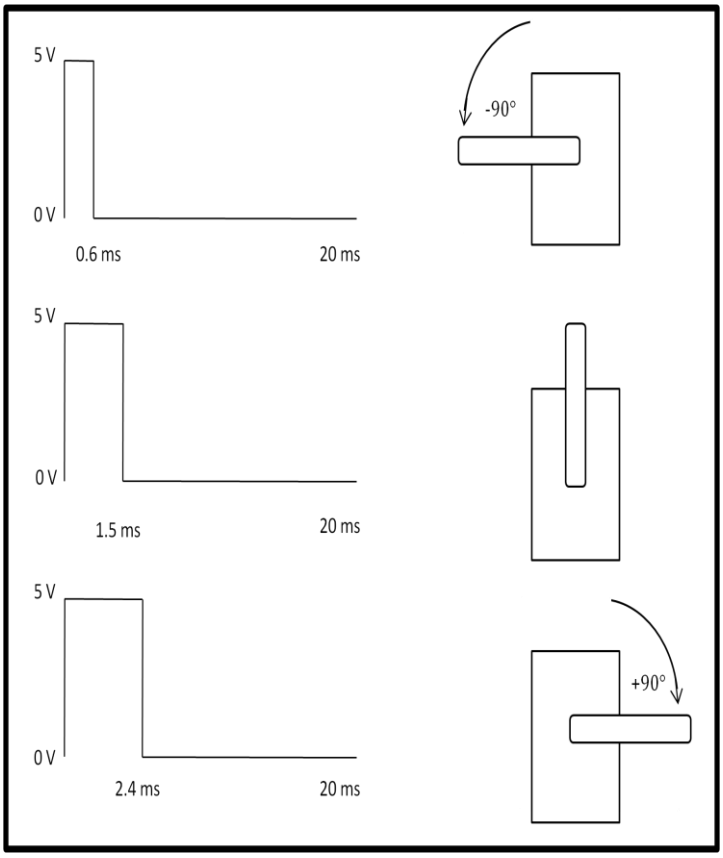

Figure 2.2: Position of motor shaft when PWM is generated.

2.2.2 INSIDE SERVO

The servo motor has some control circuits and a potentiometer (a variable resistor, a.k.a. pot) that is connected to the output shaft. In the Figure 2.3, the pot can be seen on the right side of the circuit board. This pot allows the control circuitry to monitor the current angle of the servo motor. If the shaft is at the correct angle, then the motor shuts off. If the circuit finds that the angle is not correct, it will turn the motor the correct direction until the angle is correct. A normal servo is used to control an angular motion of between 0 and 180 degrees. A normal servo is mechanically not capable of turning any farther due to a mechanical stop built on to the main output gear.

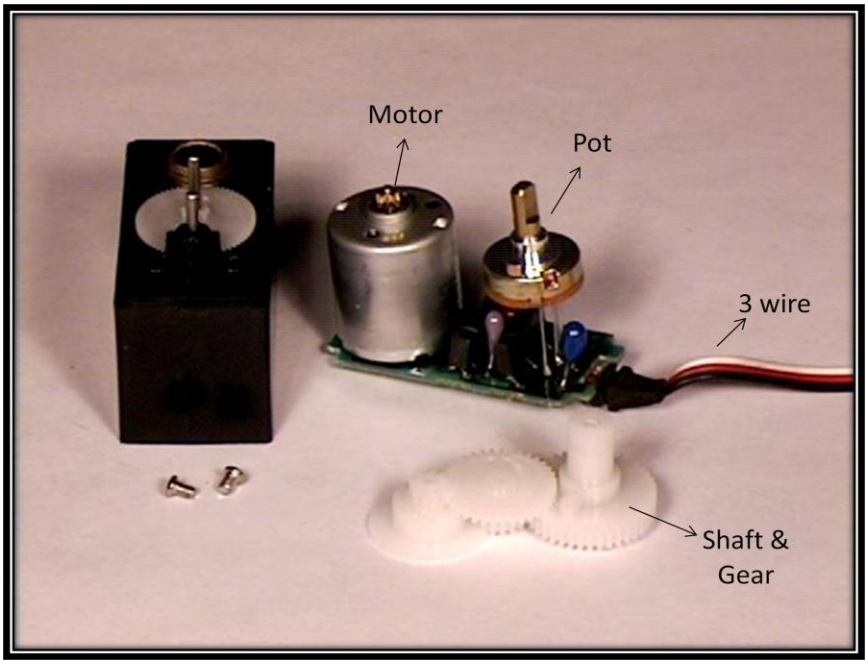

Figure 2.3: The inner part of servos.

2.3 PIC MICROCONTROLLER

For this project, the controller is used as a brain for the whole system. From the input from sensor until the output for the servo motor is controlled totally using this PIC microcontroller. Describing about the PIC microcontroller and in the mean time will be given more understanding upon employing this controller. Almost all type of PIC microcontroller is included in a class of 8-bit microcontrollers of RISC architecture. Basically, the PIC architecture is minimized to be a simpler item but it still operates at the same function. The Harvard architecture is a newer concept than von-Neumann. It was designed as a response for the need to speed up the work of a microcontroller. In Harvard architecture, data bus and address bus are separate. Thus, the data will flow directly through the central processing unit and the address bus is neglected. This greater flow of data will impact for a greater speed of work. Besides that, the architecture will involve for a small number of a fixed length instruction. It means the instruction is not to have to be 8-bit words but it can uses 14 bits for instructions which allows for all instruction to be one word instructions. Microcontrollers with Harvard architecture are called "RISC microcontrollers". RISC is a short form for Reduced Instruction Set Computer. Microcontrollers with von-Neumann's architecture are called 'CISC microcontrollers'. CISC is a short form for Complex Instruction Set Computer. Same as discussion before, RISC microcontroller has a reduced set of instructions, maybe 35 instructions for one cycle. If we compared it with Intel's and Motorola's microcontroller, it has over hundred instructions. As a simplified point, we can say that the features of PIC microcontroller are:

(i) Separate code and data spaces (Harvard architecture).
(ii) A small number of fixed length instructions.
(iii) Most instructions are single cycle execution (4 clock cycles), with single delay cycles upon branches and skips.
(iv) All RAM locations function as registers as both source and/or destination of math and other functions.
(v) A hardware stack for storing return addresses.